RESEARCH REPORT

Traffic intensity, dwelling value, and hospital admissions for respiratory disease among the elderly in Montreal (Canada): a case-control analysis

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Background: Persons exposed to residential traffic have increased rates of respiratory morbidity and mortality. As poverty is an important determinant of ill health, some have argued that these associations may relate to the lower socioeconomic status of those living along major roads.

Aims: The objective was to evaluate the association between traffic intensity at home and hospital admissions for respiratory disease among Montreal residents of 60 years and older.

Methods: Case hospitalisations were those with respiratory diagnoses and control hospitalisations were those where the primary discharge diagnosis was non-respiratory. Morning peak traffic estimates from the EMME/2 Montreal traffic model (MOTREM98) were used as an indicator of exposure to road traffic outside the homes of those hospitalised. The crude association between traffic intensity and hospitalisation for respiratory disease was adjusted by an area based estimate of the appraised value of patients' residences, expressed as a dollar average over a small segment of road (lodging value). This indicator of socioeconomic status, as calculated from the Montreal property assessment database, is available at a finer geographical scale than the neighbourhood socioeconomic indicators accessible from the Canadian census.

Results: Increased odds of being hospitalised for a respiratory compared with a control diagnosis were associated with higher levels of estimated road traffic nearby patients' homes, even after adjustment for lodging value (crude OR 1.35, CI95% 1.22 to 1.49; adjusted OR 1.18, CI95% 1.06 to 1.31 for >3160 vehicles passing during the three hour morning traffic peak compared with secondary roads off network).

Conclusion: The results suggest that road traffic intensity itself, may affect the respiratory health of elderly residents of a large Canadian city, an association that is not solely a reflection of socioeconomic status.

Exposure to traffic emissions has been associated with higher rates of mortality and hospital admissions for respiratory diseases.[1 2] A higher prevalence of respiratory disease symptoms has also been reported among those living close to heavy traffic (for example, Janssen *et al*[3] and Oosterlee *et al*[4]).

Some have argued that estimates of the effect of traffic on health may be biased upwards because of failure to control for socioeconomic status.[5] In their cohort study, Hoek and colleagues[1] found that the impact of traffic related air pollution on mortality was lower for people at higher levels of educational attainment. Given that many studies on the effects of traffic on health have relied on administrative data, area based attributes have generally been used to adjust for socioeconomic position. The attribution to people living along major roads of census data, which covers persons residing along those roads as well those living on nearby residential streets, may lead to bias: buildings located along major roads may be of lower value and attract individuals and families of lower socioeconomic status than those living in the rest of the census division.

The objectives of this study were: (1) to evaluate the impact of living along major roads in Montreal (a proxy for exposure to motor vehicle emissions) on hospitalisation for respiratory disease among older residents and (2) to remove the possible influence of lodging value on this relation.

METHODS

Population and hospitalisation data

The study group includes Montreal Island residents 60 years and older, who were admitted to a Montreal hospital between April 2001 and March 2002 for diagnoses other than trauma, tumours, tuberculosis, and heart and circulatory system disease. Hospital admissions for tuberculosis were removed to avoid bias from sociodemographic position, as in Canada the disease occurs mainly among immigrants; the three other groups of diagnoses were excluded because they may themselves be influenced by traffic exposure. Information on patients was obtained from the MED-ECHO database of the Quebec Health and Social Services Ministry. The MED-ECHO database contains a discharge summary with basic demographic data, including age, sex, the six digit postal code of residence (the exact building address of those being hospitalised is not available), and principal and secondary diagnostic coding at discharge according to the *International Classification of Diseases*, 9th version (ICD-9). There is complete participation of all hospitals in the MED-ECHO database. In Quebec, as in the rest of Canada, the health insurance programme is universal and publicly funded, which allows all residents to have ''free'' access to health care. The research ethics committee of the Montreal Regional Health Board approved the study.

Data were analysed using a semi-individual case-control approach.[6] Using ICD-9 codes at hospital discharge, diagnostic groups were created according to Buckeridge *et al* (table 1).[2] Respiratory diagnoses were considered to be cases. Non-respiratory diagnoses served as controls. Subsets of genitourinary and gastrointestinal diagnoses were selected as independent control conditions. A total of 51 322 admissions corresponding to the case and control diagnoses were identified.

Altogether 5046 admissions (9.8%) were excluded because of invalid postal codes (for example, non-residential and

Table 1 Case and control ICD-9 diagnostic codes

Diagnostic set, specific diagnosis	ICD-9 codes
Respiratory grouping	460–519
Diagnoses other than respiratory	
Infectious (other than tuberculosis)	001–009, 020–139
Endocrine, immune, and metabolic	240–279
Blood and haematopoietic	280–289
Mental disorders	290–319
Nervous system	320–389
Gastrointestinal*	520–579
Genitourinary*	580–629
Skin and subcutaneous	680–709
Musculoskeletal and connective tissues	710–739

*Also treated as independent control diagnoses.

non-existent postal codes). Fifty nine hospital admissions were excluded because of invalid health insurance numbers.

Traffic intensities and lodging values were attributed to the six digit postal codes of residence of patients at their hospitalisation as described below. In most of the city, six digit postal codes correspond to a block face. Socioeconomic census data (that is, mean household income) aggregated at the dissemination area (DA) level were also attributed to each hospital admission. DAs, which are smaller than census tracts, are composed of one or more blocks and cover a population of between 400 and 700.

From the initial 46 217 hospital admissions for which patients had valid health insurance numbers and postal codes, 1152 were excluded where traffic intensity, lodging value, or DA household income could not be assigned. Some of the hospital admissions corresponded to people who were hospitalised more than once throughout the administrative year; 433 people hospitalised more than once for a respiratory condition or for a control diagnosis moved during the administrative year. Analyses were performed for all hospital admissions (thus allowing subjects to have more than one case and/or control hospitalisation) as well as for a single case and control hospitalisation per person: in the latter circumstance, we selected one admission per person and diagnostic set randomly (as precise date of admission was unknown). The group under study consists of 35 309 people who had 45 065 hospital admissions.

Attribution of traffic intensities to residential addresses

To attribute traffic intensities to residential addresses, we used three separate databases: (1) the EMME/2 MOTREM98 database and network that has traffic intensity estimates for mapped but unnamed road segments; (2) the City of Montreal road network map with street names and addresses but without traffic intensities and, (3) the 2001 Montreal property assessment database that provides the x and y coordinates of property centroïds, their street addresses, and their assessed values.

The MOTREM98 model gives 0600 to 0900 weekday traffic intensity estimates based on an origin—destination telephone survey performed during autumn 1998. Its vectorial road network is a generalised layer that does not directly superimpose onto the real road network (that is, curves and intersections may be linearised). Information on this model can be found at http://www.inro.ca. From these data, we summed estimates of car and truck traffic for each segment of the MOTREM98 road network. Estimates for bidirectional road segments were added to obtain a single value for each road section (for example, we summed north and south going traffic on north/south street segments).

Of the 342 507 residential properties in the Montreal property assessment database, we excluded those properties where the assessment database listed either no residential lodging or had a ''building'' value under $C30 000. There were 62 351 residential properties located along roads found in the MOTREM98 of which 62 306 were attributed a six digit postal code. A traffic intensity was attributed to these 62 306 residential properties based on their proximity to the MOTREM98 road network segments as described below. All other residential properties were attributed a traffic intensity of zero.

Using Nearest Features v 3.7 script (from the ESRI commercial partner Jenness Enterprises) supplemented by manual attribution, we gave to each of the 62 306 residential properties along the MOTREM98 network the traffic intensity of the closest segment of road to the lot centroid.

Grouping traffic values by postal code

Traffic values of properties were grouped into six digit postal codes to be linked to the hospital admissions. For some postal

Table 2 Characteristics of cases and controls

		Control diagnoses		
	Respiratory grouping‡	All§	Gastrointestinal¶	Genitourinary**
Number				
Hospital admissions	5805	39260	7334	4262
Persons hospitalised* (some hospitalised more than once)	4627 (811)	30682 (6971)	6129 (913)	3473 (607)
Female, %				
Hospital admissions	52.7	59.7	49.0	49.6
Persons hospitalised	53.3	59.2	47.9	50.6
Mean age (SD)				
Hospital admissions	76.1 (8.7)	74.0 (8.0)	72.9 (8.4)	72.2 (7.9)
Persons hospitalised	76.3 (8.9)	74.0 (8.1)	72.7 (8.4)	72.1 (8.0)
Median postal code lodging value, $C†				
Hospital admissions	36700	42100	41900	45000
Persons hospitalised	37300	42100	42000	45600
Range	3100–504100	1600–1452300	1600–1452300	1600–705200
Median of mean DA household income, $C				
Hospital admissions	41600	43900	43500	44700
Persons hospitalised	41900	44000	43500	45300
Range	10600–398000	10600–398000	10600–398000	16300–398000

*A single respiratory and/or control hospitalisation was chosen randomly. †The lodging value corresponds to the average population value of lodgings. It does not correspond to building value averages, if numerous apartments are present (see Method section ''Six digit postal code lodging values''). ‡Respiratory grouping includes ICD-9 codes 460-519. §Control diagnoses includes ICD-9 001-009, 020-139, 240-389, 520-629, 680-739; trauma, tumours, tuberculosis, and circulatory system diseases were excluded. ¶Includes ICD-9 codes 520-579. **Includes ICD-9 codes 580-629.

codes, properties matched to more than one segment of the MOTREM98 network and were attributed traffic values that diverged. All postal codes for which traffic values of properties varied by more than 10% were systematically verified. After verification, 382 of the 33 165 postal codes (1.2%) had properties with variant traffic values. These included postal codes grouping different street segments and postal codes grouping different traffic segments on the same street. For these postal codes, an average of the variant road segment traffic values was calculated.

Six digit postal code lodging values
The Montreal assessment database contained a dollar value for each property as well as the number of residential units (apartments) comprising that property. The percentage of commercial value was removed from every ''property'' value to obtain a residential value. Residential ''property'' values were then summed over six digit postal codes. The sum of residential values was divided by the number of residential units within a postal code to obtain six digit postal code average lodging values, representing the average value of a living space. A number of six digit postal codes were not attributed an average lodging value because, according to the Montreal property assessment database, all residential properties within these postal codes had a value lower than $C30 000, or contained no residential units. The residential lodging value was used as an indicator of the socioeconomic level of residents of each six digit postal code.

Census dissemination area (DA) information
We used the DA mean household incomes from the 2001 Canadian census as a second indicatior of the socioeconomic position of persons hospitalised. A DA is the smallest geographical unit in the Canadian census for which socioeconomic data are available. In the census, socioeconomic information is gathered from a 20% population sample. With the use of the Canadian census postal code conversion file (PCCF) 2004, a DA was attributed to each hospital admission. For postal codes included in two DAs, the most probable DA (according to the PCCF Statistic Canada file, Ilu = 1) was assigned.

Data analysis
To evaluate the relation between traffic intensity and hospital admissions for different diagnoses, simple logistic regressions were performed (SPSS version 11.0.1 for Windows, SPSS). Specifically, with categorised postal code traffic intensities as explanatory variables, we modelled the odds of (1) any hospitalisation for a respiratory condition compared with any hospitalisation for a control diagnosis and of (2) a person being hospitalised at least once for a respiratory condition versus at least once for a control diagnosis. Multivariate logistic regressions were used to compute odd ratios (OR) and 95% confidence intervals (CI95) adjusted for age as a continuous variable, sex, postal code lodging value, proportion of multi-storey and apartment buildings by postal code and mean DA household income.

The 75% of persons hospitalised living on roads off the MOTREM98 network were attributed a traffic value of zero. The distribution of traffic values for those hospitalised and living along roads located along the MOTREM98 network was skewed and ranged from 5 to 47 430 vehicles per morning peak. Three traffic categories were created: ''low'', those residences with postal codes not adjacent to the MOTREM98 network; ''high'', those with traffic estimates greater than 3160 vehicles during the three hour morning peaks (the 75th centile for traffic values of those hospitalised and living along roads located along the MOTREM98 network); and, ''medium''. Urban highways and major collector arteries were, for the most part, included in the ''high'' traffic category; the ''medium'' traffic category includes some collector arteries and major neighbourhood streets.

RESULTS
Table 2 presents characteristics of hospitalisations in the study population. Women represented a higher proportion of respiratory cases than of non-respiratory controls but a lower proportion of exclusively gastrointestinal or genitourinary controls. Control hospitalisations were in persons younger than those for cases and related to areas where lodging values and household income were higher.

Table 3 presents the distribution of hospital admissions and of people admitted to hospital for various diagnoses within each traffic categories. Of all case and control hospitalisations, fewer than 7% related to residences along roads with three hour morning peak traffic estimates greater than 3160 vehicles. Table 4 presents the corresponding odds ratios (OR) for the association between traffic intensity and hospital admissions.

Increased odds of being hospitalised for a respiratory versus a control diagnosis were associated with living nearby to ''medium'' or ''high'' level traffic (table 4). Consistent results were seen for the effect of traffic intensity on the likelihood of hospitalisation with a respiratory diagnosis, whichever control group was used. Adjustment for sex, age, lodging value, or DA household income, reduced the ORs (table 4). After adjustment, only the OR for hospital admissions attributed to persons living on streets with a high traffic intensity remained significantly above that of the low traffic group.

With traffic intensity expressed as a continuous variable in units of 10 000 vehicles per three hour morning peak (excluding hospitalisations in persons living on roads located off the MOTREM98 network), the crude OR for the association between traffic intensity and hospitalisation for respiratory compared with all control diagnoses was 1.22 (95%CI 1.12 to 1.34). After adjustment for sex, age, and

Table 3 Distribution of admissions for cases and control diagnoses by traffic categories

		Control diagnoses		
	Respiratory grouping* (number of persons)	All diagnoses† (number of persons)	Gastrointestinal‡ (number of persons)	Genitourinary§ (number of persons)
Off traffic network (low traffic)	4081 (3286)	28844 (22600)	5448 (4563)	3235 (2648)
Medium traffic¶ (5–3160 vehicles/3 hour morning peak)	1241 (960)	7881 (6102)	1438 (1187)	820 (661)
High traffic (>3160 vehicles/3 hour morning peak)	483 (381)	2535 (1980)	448 (379)	207 (164)

*Respiratory grouping includes ICD-9 codes 460-519. †Control diagnoses includes ICD-9 001-009, 020-139, 240-389, 520-629, 680-739; trauma, tumours, tuberculosis, and circulatory system diseases were excluded. ‡Includes ICD-9 codes 520-579. §Includes ICD-9 codes 580-629. ¶Traffic intensities correspond to the estimates of peak morning three hour traffic volumes from the MOTREM98 EMME/2 model.

Table 4 Association between traffic intensity and elderly respiratory hospital admissions* compared with control diagnoses

Type of control groups	Crude OR (95%CI)	OR adjusted for age, sex (95%CI)	OR adjusted for age, sex, lodging value (95%CI)	OR adjusted for age, sex, DA** household income (95%CI)
All diagnoses†				
Traffic intensity‡				
Off traffic network	1.00	1.00	1.00	1.00
1–3160 vehicles/3 hour morning peak	1.11 (1.04 to 1.19)	1.09 (1.02 to 1.17)	1.05 (0.98 to 1.12)	1.08 (1.00 to 1.15)
>3160 vehicles/3 hour morning peak	1.35 (1.22 to 1.49)	1.30 (1.17 to 1.44)	1.18 (1.06 to 1.31)	1.24 (1.12 to 1.38)
Gastrointestinal§				
Traffic intensity				
Off traffic network	1.00	1.00	1.00	1.00
1–3160 vehicles/3 hour morning peak	1.15 (1.06 to 1.26)	1.10 (1.01 to 1.20)	1.07 (0.98 to 1.17)	1.10 (1.00 to 1.20)
>3160 vehicles/3 hour morning peak	1.44 (1.26 to 1.65)	1.32 (1.15 to 1.52)	1.21 (1.05 to 1.39)	1.28 (1.11 to 1.47)
Genitourinary¶				
Traffic intensity				
Off traffic network	1.00	1.00	1.00	1.00
1–3160 vehicles/3 hour morning peak	1.20 (1.09 to 1.33)	1.15 (1.04 to 1.27)	1.10 (0.99 to 1.22)	1.13 (1.02 to 1.26)
>3160 vehicles/3 hour morning peak	1.85 (1.56 to 2.19)	1.67 (1.41 to 1.99)	1.46 (1.22 to 1.74)	1.57 (1.32 to 1.87)

*Respiratory grouping includes ICD-9 codes 460-519. †Control diagnoses includes ICD-9 001-009, 020-139, 240-389, 520-629, 680-739; trauma, tumours, tuberculosis, and circulatory system diseases were excluded. ‡Traffic intensities correspond to the estimates of peak morning three hour traffic volumes from the MOTREM98 EMME/2 model. §Includes ICD-9 codes 520-579. ¶Includes ICD-9 codes 580-629. **Census dissemination area.

lodging value, the OR for traffic intensity as a continuous variable, excluding those hospitalisations among persons living off the MOTREM network, for respiratory compared with all control diagnoses, was 1.19 per 10 000 vehicles (95CI 1.09 to 1.30). After adjustment for sex, age, and average DA household income, the corresponding OR for traffic intensity as a continuous variable was 1.21 per 10 000 vehicles (95%CI 1.11 to 1.32).

Both six digit postal code lodging value and average DA household income were inversely related to the odds of being hospitalised for respiratory disease (the OR for the association between lodging value or DA household income and respiratory compared with all control hospitalisations were respectively 0.62 per $100 000 of lodging value, 95%CI95 0.58 to 0.67, and 0.53 per $100 000 of DA household income, 95%CI: 0.47 to 0.60, after adjustment for age and sex). Both postal code lodging value and DA average household income were inversely related to traffic intensity (Spearman ρ for postal code lodging value and DA household income with traffic intensity: −0.23 and −0.10 respectively, $p<0.001$). Adjustment for lodging value was stronger than adjustment for average DA income in reducing the crude association between traffic intensity and respiratory hospitalisation.

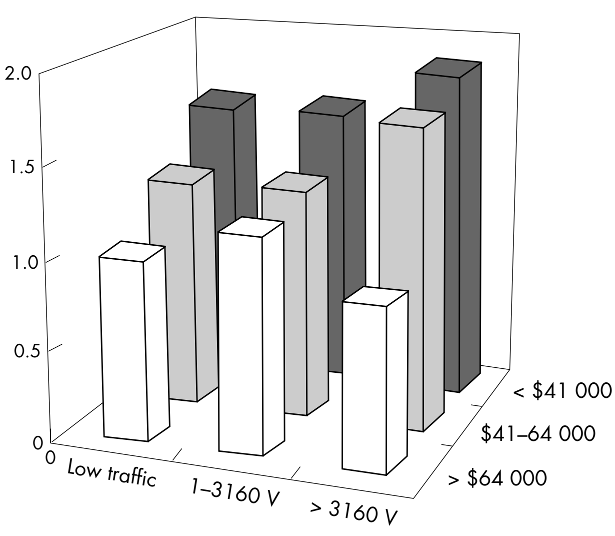

Figure 1 Odd ratios (OR) for the association between traffic intensity, lodging value, and elderly hospital admissions for respiratory problems. Lodging values of $41 000 correspond to the 50th centile of the lodging value distribution; a lodging value of $64 000 corresponds to the 75th centile. No conclusions can be drawn from the high traffic high lodging value given the small number of admissions.

What is already known on this subject

Traffic intensity and traffic related pollutants have been associated with increased respiratory morbidity and mortality. These associations may be biased by the fact that socioeconomically disadvantaged persons may live disproportionately along major roads.

Including the proportion of multistorey and apartment buildings in a postal code had minimal impact in adjusting the association between traffic intensity and respiratory hospitalisation (data not shown). This may reflect the observation that the lowest lodging values are mostly those of apartment buildings.

Various analyses were performed to estimate the influence of exposure measurement error. Results similar to those presented in table 4 were seen when people admitted to a hospital during the study period were considered as cases and controls, instead of hospitalisations. Similar results were also seen when analyses were performed excluding hospitalisations among persons with more than one address, hospitalisations where persons' residences matched to more than one segment of the MOTREM98 network, and persons living along one way streets of the MOTREM98 network (as some one way streets may receive important traffic flow only during the evening traffic peaks, data not shown).

To better visualise the results, figure 1 presents the ORs for hospital admissions for a respiratory condition, compared with all other diagnoses, by traffic level and lodging value, as derived from a multiple logistic model, adjusted for age and sex. ORs for all strata were significantly different ($p<0.01$) than the low traffic-high lodging value class, except for the high traffic-high lodging value group, which included only 24 hospitalisations. The high traffic-low lodging value group was also significantly different than the low traffic-low lodging value (1.16, 1.04 to 1.31).

DISCUSSION

The risk of hospitalisation for respiratory disease in the elderly is increased for those living along roads with higher

What this study adds

- In Montreal, elderly persons living along major roads are at higher risk of being hospitalised for respiratory illnesses, which seems to be attributable not solely to the fact that those living along major roads are at relative economical disadvantage.
- In population health studies, property assessments can portray socioeconomic status at a smaller scale and with greater geographical flexibility than the commonly used indicators derived from census data.

traffic intensities. Analyses do, however, show the presence of confounding by socioeconomic status. We propose the use of property assessment databases as a means of adjusting for socioeconomic position in population based health studies: relative to adjustment on the basis of income averaged over multi-block census tracts, property assessments may permit assessment at a more pertinent spatial level.

The association between traffic intensity and hospitalisation for respiratory disease in the elderly may be related to vehicle emissions as well as to emissions from brake and tyre wear, road dust and noise, and psychological stress. Vehicle emissions are a complex mixture of thousands of gaseous and particulate organic and inorganic compounds. Major constituents include hydrocarbons, nitrogen oxides, carbon monoxide and dioxide, and particles. Particles emitted are of varying sizes and adsorbed compounds.[7] In Montreal, levels of traffic related particles are higher along major roads. In previous work, we found that absorbance of PM2.5 filters measured at a site with a traffic intensity of 7700 vehicles per three hours morning peak was 38% higher than that measured at a ''background'' site.[8]

Inconsistencies have been seen between studies on the health impact of traffic emissions (examples of negative studies: Livingstone *et al*,[9] Venn *et al*,[10] and Wilkinson *et al*[11]). Such inconsistencies may be attributable to differing designs, the variety of effects measured, and to confounding. Inconsistencies may also be attributable to differences in exposure measurement. Most studies have relied on the distance to major roads and on measured or self reported traffic intensities as a proxy for exposure (see Brauer *et al*[12] for a review).

We have assessed traffic intensity at the street address at which hospitalised patients lived because pollutants such as nitrogen dioxide and particulate levels are greatly reduced within a few metres from the kerb.[13–15] However, non-differential exposure misclassification is likely to be present to some extent. For example, a building (or part of it) may be closer to another street than to its listed street location (for example, a building at an intersection) or the backyard of a house on a quiet street may be adjacent to a highway. Furthermore, as our traffic estimates were at the streetside postcode level, we were unable to assess influence of building height on exposure to traffic emissions.

Policy implication

Public policy interventions should target residential areas with high traffic intensities, especially as such exposure increases the already higher risk of hospitalisation for respiratory diseases in poor areas.

Others have proposed that inconsistencies between studies may relate to confounding by socioeconomic status.[5] In this study, we explored the potential impact of socioeconomic confounding on the association between traffic intensity and hospital admission for respiratory diagnoses, using separately information from the Montreal property assessment database and aggregate mean household income derived from the census DA. Information at the individual level was not available to explore the potential impact of socioeconomic confounding and our adjustment could only be on a small area basis. None the less, six digit postal code lodging values provided a larger change in the OR for the association between traffic intensity and hospital admission than DA aggregate mean household income. This may be attributable to the fact that lodging value may convey information beyond that of the financial status of persons hospitalised. In Montreal, residences most likely to present indoor air quality problems (such as the presence of cockroaches or mould) are those in areas where lodging values are lower (data not shown). On the other hand, six digit postal code lodging values may also provide a larger change in the OR for the association between traffic intensity and respiratory hospital admission than mean household income by DA, because the latter may misclassify the socioeconomic status of those living along major roads, as these represent only a part of the DA.

Exposure to tobacco smoke has been associated with hospital admissions for respiratory disease.[16] In this study, information on smoking was not available at the individual level. Likewise, we had no information on smoking at the level of census DA or six digit postal codes. As smoking behaviour is likely to be associated with the socioeconomic status of those hospitalised, adjustment of the association between traffic intensity and respiratory hospital admissions, for either dwelling values or census data, are likely to control, at least partly, for the smoking behaviour of those hospitalised.

The results of this study establish the presence of an association between traffic intensity and hospital admissions for respiratory disease in the elderly. Cases living along major roads may have been sick before moving there and may have relocated towards major roads, as their means declined coincident to failing health. On the other hand, sick people may have moved from major roads because of their illness. As exposure assessment is based on residence at time of admission, this study cannot assess the impact of migration towards or away from major roads. Furthermore, there is no information on duration of residential exposure as would be required to define the induction period for the effect of traffic. Although imperfect, the results of this study support evidence that levels of vehicle emissions within a Canadian city have an impact on the respiratory health of elderly citizens, which seems to be attributable not simply to their socioeconomic status. While important for the population that lives along major roads, the attributable risk of immediate traffic on the occurrence of respiratory disease in the population as a whole, would seem moderate. Indeed only about 7% of lodging units are located along major roads with a volume of more than 3160 vehicles during the three hour morning peak. The extent of confounding by residents' socioeconomic status should be explored through the use of the property assessment database, or other measures, in cities with varying mixtures of traffic, demography, and socioeconomic status.

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REFERENCES

1 **Hoek G**, Brunekreef B, Goldbohm S, *et al.* Association between mortality and indicators of traffic-related air pollution in the Netherlands: a cohort study. *Lancet* 2002;**360**:1203–9.
2 **Buckeridge DL**, Glazier R, Harvey BJ, *et al.* Effect of motor vehicle emissions on respiratory health in an urban area. *Environ Health Perspect* 2002;**110**:293–300.
3 **Janssen NA**, Brunekreef B, van Vliet P, *et al.* The relationship between air pollution from heavy traffic and allergic sensitization, bronchial hyperresponsiveness, and respiratory symptoms in Dutch schoolchildren. *Environ Health Perspect* 2003;**111**:1512–18.
4 **Oosterlee A**, Drijver M, Lebret E, *et al.* Chronic respiratory symptoms in children and adults living along streets with high traffic density. *Occup Environ Med* 1996;**53**:241–7.
5 **Delfino RJ**. Epidemiologic evidence for asthma and exposure to air toxics: linkages between occupational, indoor, and community air pollution research. *Environ Health Perspect* 2002;**110**(suppl 4):573–89.
6 **Künzli N**, Tager IB. The semi-individual studyi air pollution epidemiology: a valid design as compared to ecologic studies. *Environ Health Perspect* 1997;**105**:1078–83.
7 **Holman C**. Sources of air pollution. In: Holgate ST, Samet J, Koren HS, *et al*, eds. *Air pollution and health*. San Diego: Academic Press, 1999:115–48.
8 **Smargiassi A**, Baldwin M, Pilger C, *et al.* Small-scale spatial variability of particle concentrations and traffic levels in Montreal: a pilot study. *Sci Total Environ* 2005;**338**:243–51.
9 **Livingstone AE**, Shaddick G, Grundy C, *et al.* Do people living near inner city main roads have more asthma needing treatment? Case control study. *BMJ* 1996;**312**:676–7.
10 **Venn A**, Lewis S, Cooper M, *et al.* Local road traffic activity and the prevalence, severity, and persistence of wheeze in school children: combined cross sectional and longitudinal study. *Occup Environ Med* 2000;**57**:152–8.
11 **Wilkinson P**, Elliott P, Grundy C, *et al.* Case-control study of hospital admission with asthma in children aged 5–14 years: relation with road traffic in north west London. *Thorax* 1999;**54**:1070–4.
12 **Brauer M**, Hoek G, van Vliet P, *et al.* Estimating long-term average particulate air pollution concentrations: application of traffic indicators and geographic information systems. *Epidemiology* 2003;**14**:228–39.
13 **Roorda-Knape MC**, Janssen NAH, de Hartog JJ, *et al.* Air pollution from traffic in city districts near major motorways. *Atmosph Environ* 1998;**32**:1921–30.
14 **Zhu Y**, Hinds WC, Kim S, *et al.* Concentration and size distribution of ultrafine particles near a major highway. *J Air Waste Manag Assoc* 2002;**52**:1032–42.
15 **Gilbert NL**, Woodhouse S, Stieb DM, *et al.* Ambient nitrogen dioxide and distance from a major highway. *Sci Total Environ* 2003;**312**:43–6.
16 **Zaher C**, Halbert R, Dubois R, *et al.* Smoking-related diseases: the importance of COPD. *Int J Tuberc Lung Dis* 2004;**8**:1423–8.

APHORISM OF THE MONTH

"Everybody's greedy except you and me (and even you seem greedy sometimes)."

Virtually everyone in the work world is motivated by ego, cash, pruriency, or some combination of those. Some, like you and me, need only be reminded of the virtuous aspects of our labour. But we are rare, so don't depend on it!

Lowell Levin